Field Report for Airborne Data Collected
In Support of US EPA Region 6
South 4 Group Fire
02 December 2019

Background

On 27 November 2019 an explosion and subsequent fire was reported at the South 4 Group facility located near Port Neches, TX. Local information indicated that at approximately 0100 (central) a large explosion rocked the area. The explosion subsequently caused a massive fire at the facility in a short amount of time. Local officials ordered an initial evacuation of 0.5 miles on 27 November 2019 which was extended to 4 miles around 1430 (central). The evacuation order was lifted at 1000 (central) on 29 November 2019. Reported onsite products include various olefins, butadiene, and isobutylene. The geographical coordinates of the facility are 29.9222N, 95.0547W (figure 1).

The US EPA Region 6 requested that the ASPECT system be deployed to provide monitoring support beginning on 27 November 2019. This report summarizes findings observed during the two missions flown on 02 December 2019.

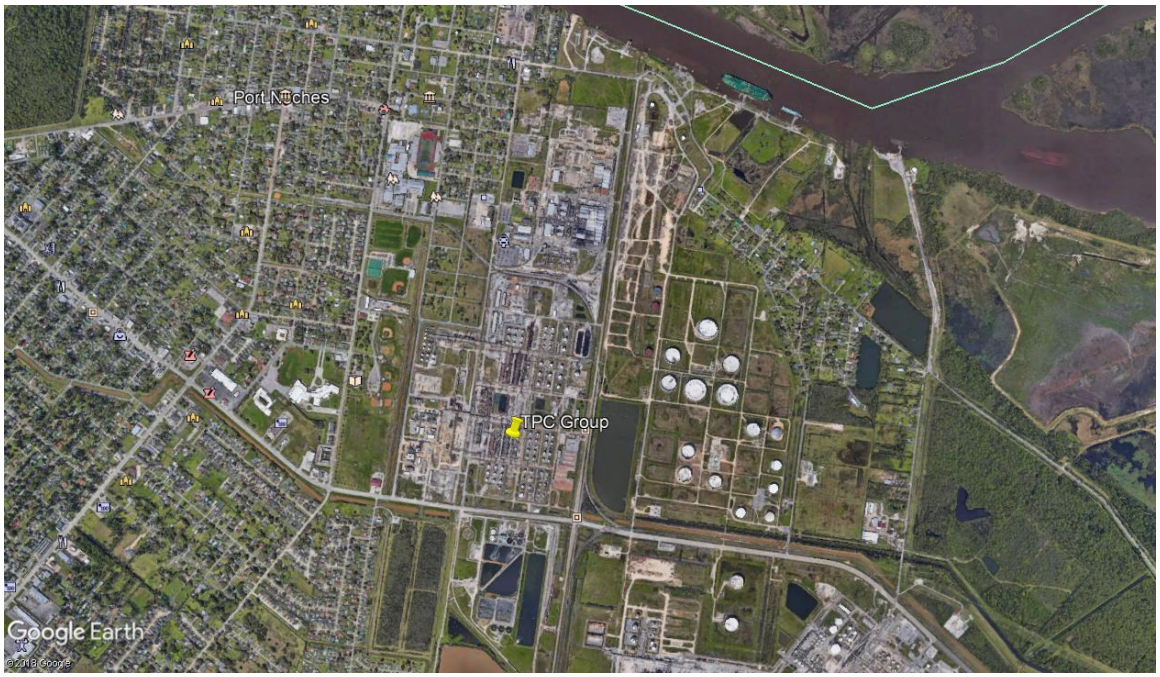

Figure 1: South 4 Group Facility, Port Neches, TX

ASPECT response to this Mission/Incident was in support of:
US EPA Region 6. OSC: Adam Adams

9989553

On 27 November 2019 ASPECT was dispatched to collect aerial remote sensing data over the South 4 Group facility located near Port Neches, TX and conducted three data collection missions. An explosion and fire involving a production unit and subsequent tank farms resulted in a black plume moving toward the south. Reports from the air crew indicated that significant lofting was occurring with smoke reaching 4000 feet above ground. Collected spectral data from both the IRLS and FTIR did not show any chemical detections. Data analysis from the second and third mission showed consistency to that of the first with the presence of a large thermal signature with the absence of detected compounds.

Due to poor weather and very low ceilings, ASPECT was only able to collect a few oblique images on 28 November 2019 and did not fly at all due to poor weather on 29 November 2019. On 30 November 2019 ASPECT collected aerial remote sensing data over the South 4 Group facility located near Port Neches, TX. Analysis of FTIR data did not show any chemical detections. IR image analysis showed the presence of elevated temperatures within the reactor complex, but the magnitude was substantially reduced from prior missions. Visible imagery showed only a light grey plume being generated at the facility with no active fires immediately visible. Damage to the facility and nearby spherical tanks was clear in the aerial and obliques images.

ASPECT conducted two flights on 01 December 2019. Analysis of IR imagery collected during the morning flight on 01 December 2019 indicated that isolated elevated thermal locations still exist within the production unit. Visible imagery confirmed that crew reports of light gray smoke was being emitted from the facility and was moving in an easterly direction. FTIR data collected in the vicinity of the facility showed one detection of isobutylene near the Orchard Ave bridge. The estimated concentration was about 1 ppm. Analysis of IR imagery of the junction of the waterway east of the facility which intersects with the Naches River showed no evidence of oil sheen. The afternoon showed a low thermal environment within the process unit and minimal smoke being emitted from the site. The analysis of imagery showed that four water cannons were being employed at the facility. IR imagery did not show any oil sheen presence on the Neches River. Analysis of FTIR data showed detections of isobutylene south of the facility near the wastewater treatment plant. These detections were approximately 1.7 ppm on two separate passes.

ASPECT was requested by Region 6 to conduct morning and afternoon data collection flights downwind, upwind and up the wind axis in reference to the facility. In addition, drainage ways into the Neches River were also be imaged. This report details results and information from mission conducted on 02 December 2019.

ASPECT System

The US EPA ASPECT system collects airborne infrared (IR) images and chemical screening data from a safe distance over the site (about 3,000 ft AGL). The system

consists of an airborne high-speed Fourier transform infrared spectrometer (FTIR) coupled with a wide-area IR line scanner (IRLS). The ASPECT IR systems can detect compounds in both the 8 to 12-micron (800 to 1200 cm-1) and 3 to 5 micron (2000 to 3200 cm-1) regions. The 8 to 12-micron region is typically known as the atmospheric window region since the band is reasonably void of water and carbon dioxide influence. Spectrally, this region is used to detect carbon - non-carbon bonded compounds. The 3 to 5-micron region is also free of water and carbon dioxide but typically does not have enough energy for use. This band does show use in high-energy environments such as fires. The carbon - hydrogen stretch is very common in this region.

A digital Nikon DX2 camera (12.4 mega pixel CMOS 3:5 aspect ratio, 28 mm wide-angle lens) collects visible aerial imagery as part of the core data product package. The camera timing system is connected to the primary IR sensors and provides concurrent image collection when other sensors are triggered. All imagery is geo-rectified using both aircraft attitude correction (pitch, yaw, and roll) and GPS positional information. Imagery can be processed while in flight or approximately 600 frames per hour can be processed once the data are downloaded from the aircraft.

An Imperx mapping camera (29 mega pixels; mapping focal plane array) provides a similar aspect ratio and aerial coverage. Like the Nikon DX2, it is connected to the primary IR sensors and provides concurrent image collection when other sensors are triggered. These images are often digitally processed in lower resolution, so they can be transmitted via satellite communication. The high-resolution images (>20 MB each) are pulled from the ASPECT after the sortie and are available later.

All high resolution digital aerial photographic images collected by the ASPECT system are ortho-rectified and geospatially validated by the reach back team. In general, this consists of conducting geo-registration using a Digital Elevation Model (DEM) which promotes superior pixel computation and lessens topographic distortion. The image is then check by a team member (using a Google Earth base map) for proper location and rotation

Data is processed using automated algorithms onboard the aircraft with preliminary results being sent using a satellite system to the ASPECT reach back team for QA/QC analysis. Upon landing preliminary data results are examined and validated by the reach back team.

Flight Results for Flight 10, 02 December 2019

Weather Conditions and Crew Report

Weather for the morning mission are given in table 1.

Table 1. South 4 Group Mission Weather

Parameter	Surface (0700)	Surface (0800)	Surface (0900)
Wind direction	337 degrees	337 degrees	000 degrees
Wind speed	4.5 m/s (10 mph)	6.2 m/s (14 mph)	5 m/s (11 mph)
Temperature	6.7ºC	9.4ºC	16ºC
Humidity	65%	52%	44%
Dew Point	0.6ºC	0ºC	0ºC
Pressure	1024 mb	1024 mb	1024
Ceiling	Clear	Clear	Clear

The crew reported that winds at altitude (2800 ft) were at about 25 kts (12.8 m/s) from the northwest (327 degrees). There was no visible plume leaving the site. At the beginning of the flight, there was one fire cannon which was increased to 4 cannons at the end.

Flight Status

The order to launch flight 10 was given at 0700 central on 02 December 2019 with the aircraft reporting wheels up at 0718. The initial data collection run over the site was at 0749 (central) The aircraft made a total of 8 data collection passes; flight information is summarized in Appendix Flight #10 and Figure 2.

Data Results

General Data Quality Objective

The following general data quality objectives are employed in conducting emergency response data collection with ASPECT:

1. To support overall situational analysis of the incident including aerial photography and IR imagery
2. To screen the incident for the presence of selected chemicals
3. To estimate the location and concentration of plumes being generated by the incident.

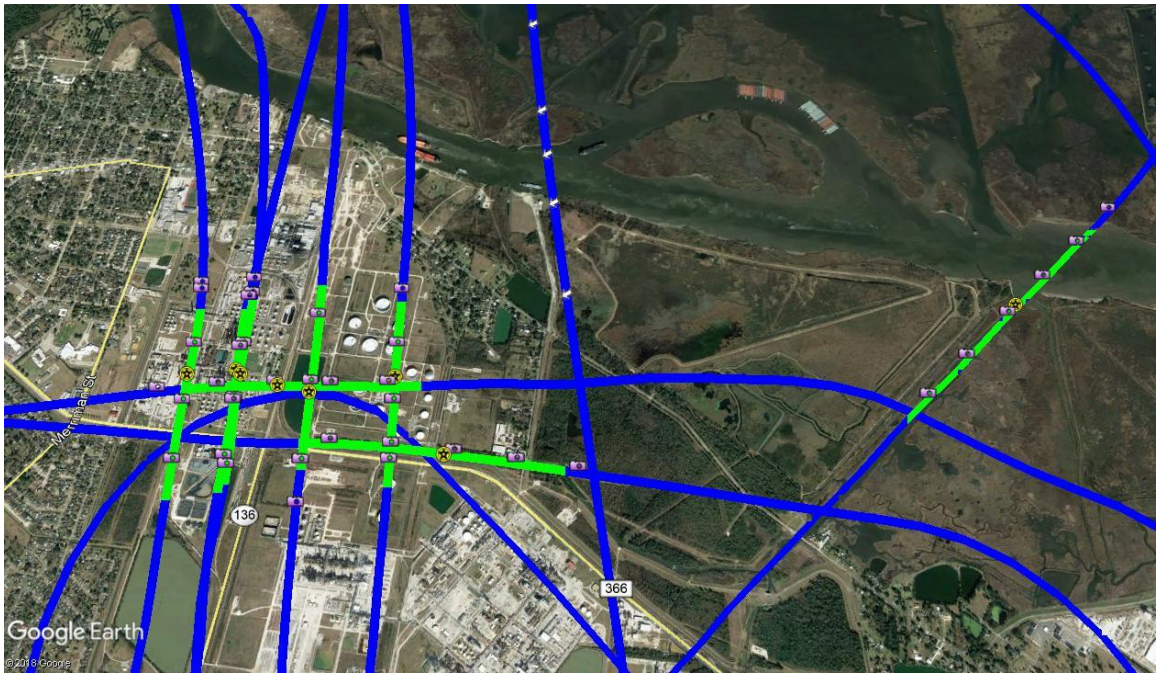

Figure 2: Data collection passes, Flight 10, South 4 Group Fire, Port Neches, TX. The blue lines represent the ASPECT flight path, green lines represent when the FTIR was actively collecting data, the yellow icons with star is the centroid of the line scanner image, and the camera icons represent when a photo was taken.

Line Scanner Data Results

A total of 2 test and 8 data collection passes were made in the proximity of the fire and an infrared line scanner image was generated for each pass. Figure 3 shows a typical 3-band infrared image obtained from data collected for Run 8. The thermal environment of the unit tends to be low. At the time of the IR collection, no water cannon or emissions can be seen in the image. Figure 4 shows a close-up thermal analysis of the production facility again showing very little elevated temperature other what appears to be one hot spot on the northern side of the process unit.

To check for possible oil migration from the site, ASPECT was flown along a waterway leading from the east side of the facility to the Naches River. Figure 5 show an IR image of the waterway flowing into the River. No sheen can be seen in the image.

FTIR Data Results

FTIR Spectral data at a resolution of 16 wavenumbers was collected for each pass. ASPECT uses an automated detection algorithm to permit compounds to be analyzed while the aircraft is in flight. 72 compounds are included in this algorithm and the list is given

in Table 2. In addition, collected data are also manually analyzed by comparing any detected spectral signatures to a collection of published library spectra.

There were no chemical detections on the morning mission. A summary of data of the data collection is given in table 3.

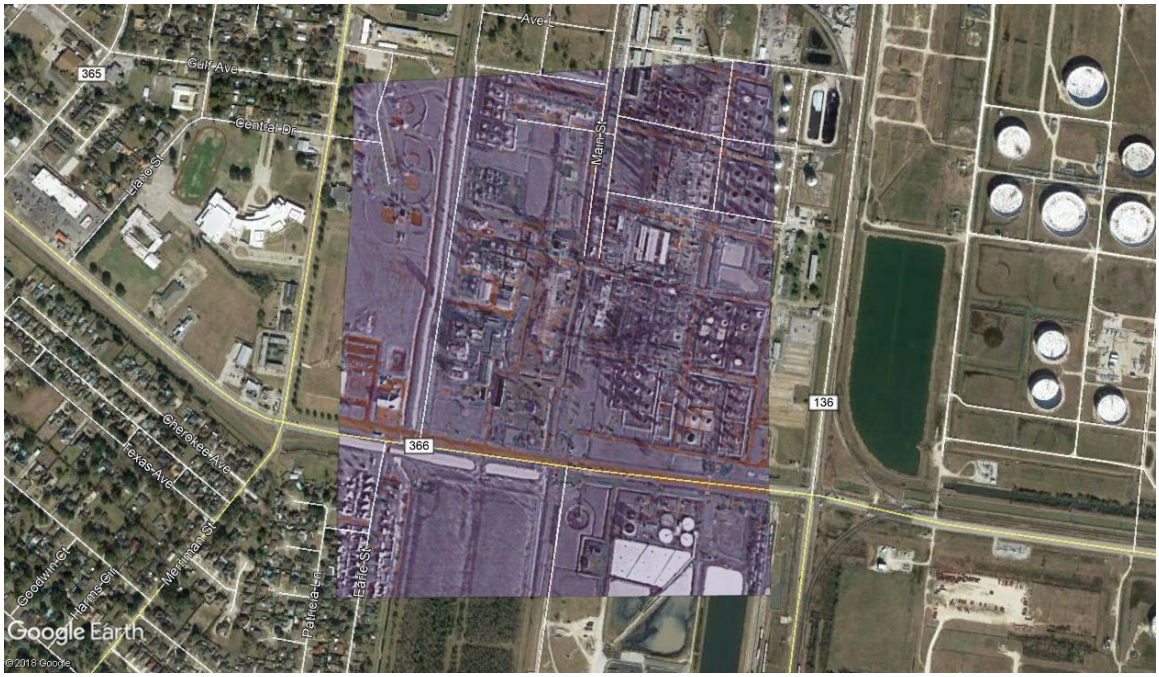

Figure 3: – 3 band IR image, Flight 10, Run 8, South 4 Group Fire

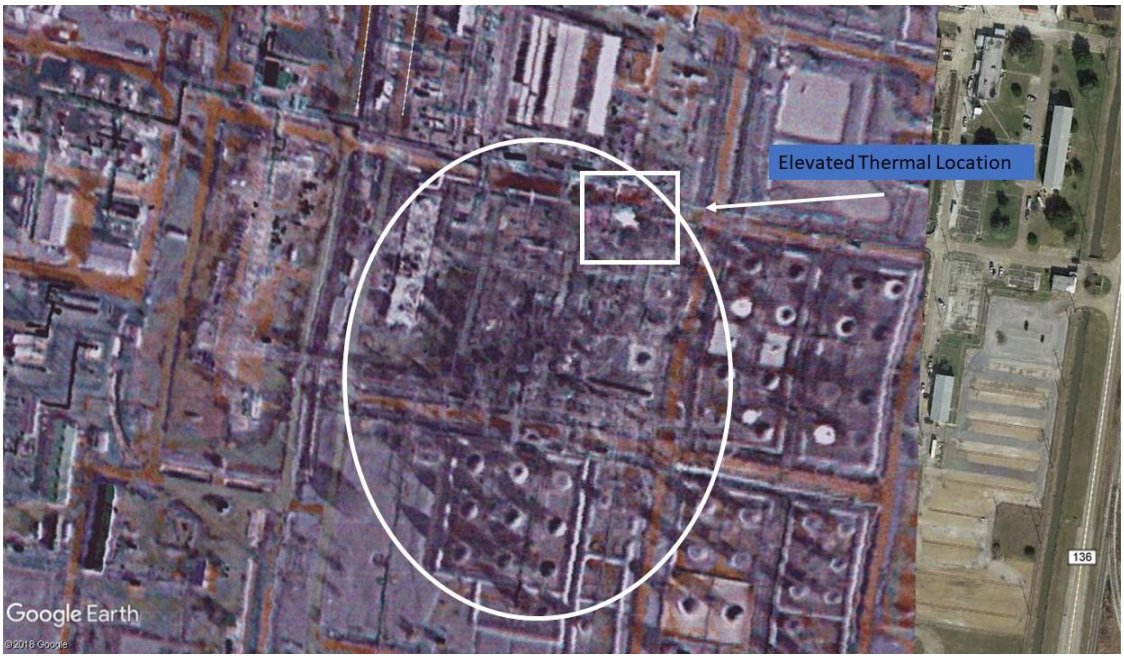

Figure 4: -- 3 band IR Image, Flight 10, Run 8, South 4 Group Thermal Image

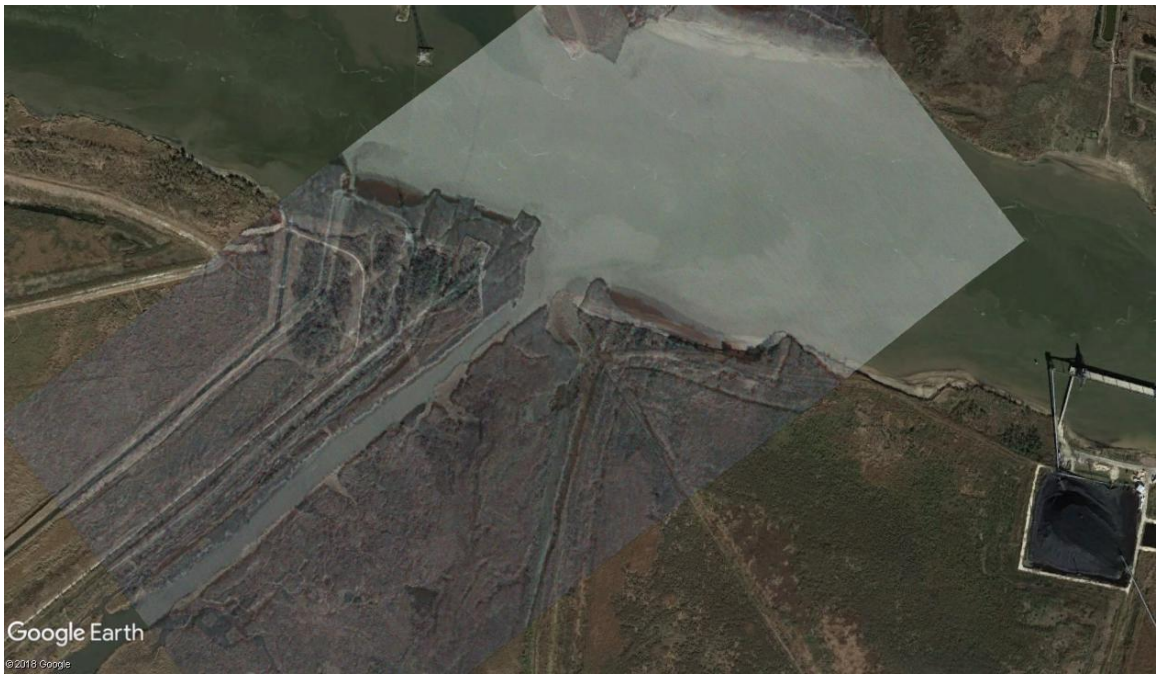

Figure 5: -- 3 band IR Image, Flight 10, Run 10, Waterway Image, South 4 Group Fire

TABLE 2 - Chemicals Included in the ASPECT Auto-Processing Library

Acetic Acid	Cumene	Isoprene	Propylene
Acetone	Diborane	Isopropanol	Propylene Oxide
Acrolein	1,1-Dichloroethene	Isopropyl Acetate	Silicon Tetrafluoride
Acrylonitrile	Dichloromethane	MAPP	Sulfur Dioxide
Acrylic Acid	Dichlorodifluoromethane	Methyl Acetate	Sulfur Hexafluoride
Allyl Alcohol	Difluoroethane	Methyl Ethyl Ketone	Sulfur Mustard
Ammonia	Difluoromethane	Methanol	Nitrogen Mustard
Arsine	Ethanol	Methylbromide	Phosgene
Bis-Chloroethyl Ether	Ethyl Acetate	Methylene Chloride	Phosphine
Boron Tribromide	Ethyl Formate	Methyl Methacrylate	Tetrachloroethylene
Boron Triflouride	Ethylene	MTEB	1,1,1-Trichloroethane
1,3-Butadiene	Formic Acid	Naphthalene	Trichloroethylene
1-Butene	Freon 134a	n-Butyl Acetate	Trichloromethane
2-Butene	GA (Tabun)	n-Butyl Alcohol	Triethylamine
Carbon Tetrachloride	GB (Sarin)	Nitric Acid	Triethylphosphate
Carbonyl Chloride	Germane	Nitrogen Trifluoride	Trimethylamine
Carbon Tetraflouride	Hexafluoroacetone	Phosphorus Oxychloride	Trimethyl Phosphite
Chlorodifluoromethane	Isobutylene	Propyl Acetate	Vinyl Acetate

Table 3. Chemical Results Summary

Run	Date	Time (UTC)	Chemical	Max Concentration ppm
1	2 Dec 2019	1333	Test	Test
2		1336	Test	Test
3		1349	ND	None
4		1354	ND	None
5		1400	ND	None
6		1407	ND	None
7		1416	ND	None
8		1424	ND	None
9		1431	ND	None
10		1437	ND	None
Note: ND = No Detections				

Aerial Photography Results

A full set of high resolution aerial digital photography were collected as part of the flight. Figure 6 shows a representative image collected as part of each pass. Consistent with the crew report, a small amount of smoke was observed being emitted from the site. The oblique image in Figure 7 shows the presence of one fire on the north side of the unit. At the time of the oblique collection, one water cannon was in operation.

Conclusions – Flight 10

Analysis of IR imagery collected during the morning flight on 02 December 2019 indicated that very little thermal content was present in the process unit other than one fire on the north side of the unit. Visible imagery showed one water cannon in operation and light gray smoke being emitted from the facility due to the one fire. There were no chemical detections in the proximity of the facility. Analysis IR imagery of the junction of the waterway east of the facility which intersects with the Naches River showed no evidence of oil sheen.

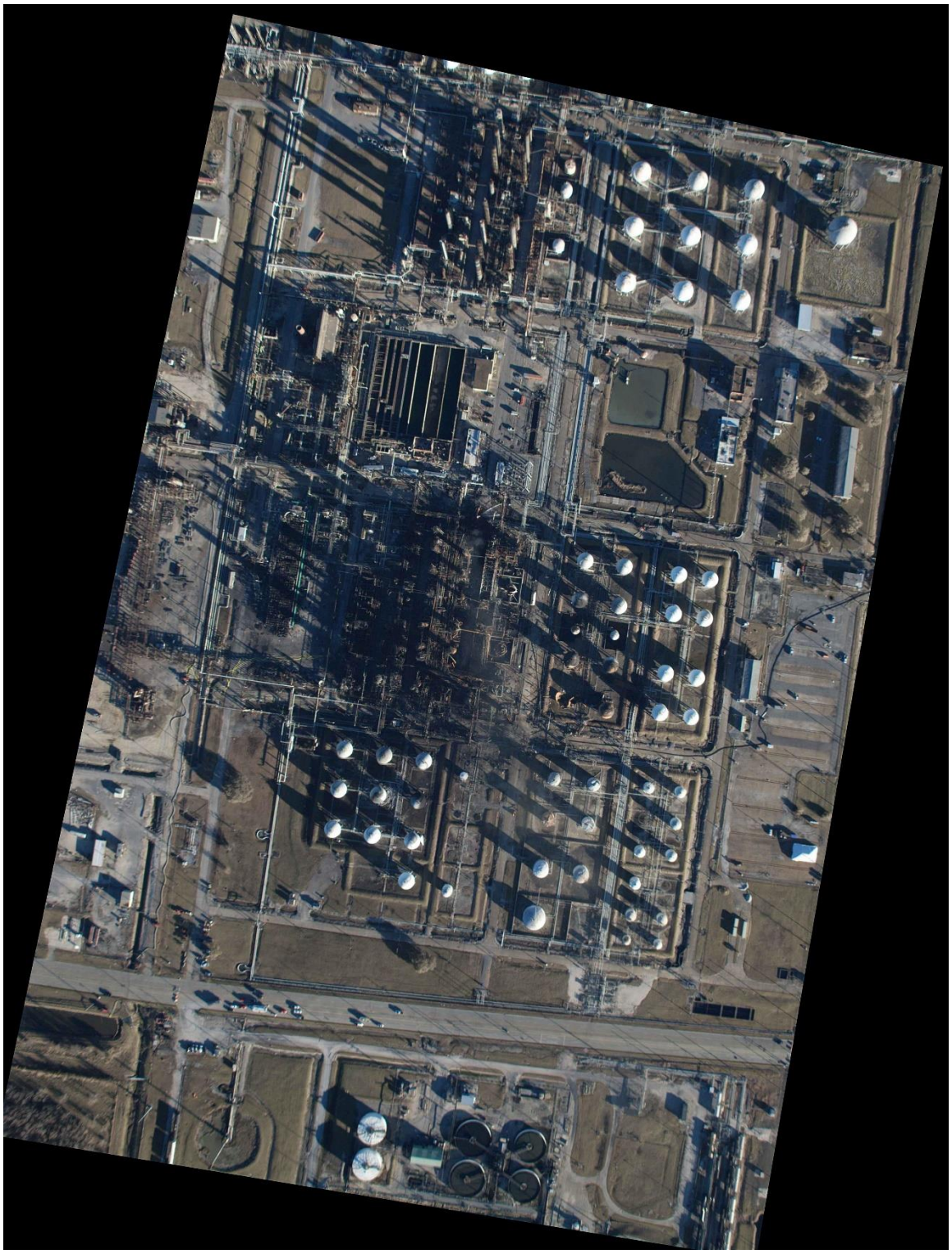

Figure 6: Aerial Image, Flight 10, Run 6, South 4 Group Fire.

Figure 7: Oblique Image of the South 4 Group Fire

Appendix Flight #10

Abbreviations:

DEM – Digital elevation model
Alt – Altitude (in feet)
MSL – Mean sea level altitude (in feet)
Digital – Digital photography file from the Nikon D2X camera
MSIC – Digital photography file from the Imperx mapping camera
FTIR – Spectral IR data collected with a Fourier Transform Infrared Spectrometer
IRLS – Infrared Line Scanner
Jpg – JPEG image format
UTC – Universal Time Coordinated
img – Spectral data format based on Grams format

Mission: 2019-12-02 South 4 Group Fire

Date: 12/2/2019
Time UTC: 13:26

Aircraft Number: N9738B
Pilot: Todd Seale
Copilot: James Glaviano
Operator: James Crisp
Aft Operator: Gerry Broyles
Ground Controller: Ahmed Hafez

DEM: Using elevation from DEM Database

Run: 1 Time: 13:33:11 UTC
  Alt: 2698 ft MSL Elev: 6 ft Elevation from DEM Database
  Vel: 139 knots Heading: 276

Digitals: None
MSIC: 3
  20191202133317944.jpg
  20191202133324293.jpg
  20191202133330642.jpg
FTIR: 1
  20191202_133314_A.igm
IRLS: 1
  2019_12_02_13_33_15_R_01 TA=3.1;TB=22.9;Gain=3
Gamma Runs: None

Run: 2 Time: 13:36:26 UTC
  Alt: 2704 ft MSL Elev: 0 ft Elevation from DEM Database
  Vel: 180 knots Heading: 185

Digitals: None
MSIC: 3
  20191202133632237.jpg
  20191202133639491.jpg
  20191202133645856.jpg
FTIR: 1
  20191202_133629_A.igm
IRLS: 1
  2019_12_02_13_36_31_R_02 TA=-3.0;TB=17.6;Gain=3
Gamma Runs: None

Run: 3 Time: 13:49:21 UTC
  Alt: 2770 ft MSL Elev: 7 ft Elevation from DEM Database
  Vel: 104 knots Heading: 353

```
Digitals:  None
MSIC: 5
        20191202134926711.jpg
        20191202134933966.jpg
        20191202134940331.jpg
        20191202134946680.jpg
        20191202134948490.jpg
FTIR: 1
        20191202_134925_A.igm
IRLS: 1
        2019_12_02_13_49_25_R_03 TA=1.2;TB=21.2;Gain=3
Gamma Runs:  None

-----------------------------------------------------------------------

Run: 4 Time: 13:54:23 UTC
        Alt: 2640 ft MSL  Elev: 8 ft  Elevation from DEM Database
        Vel: 130 knots  Heading: 186

Digitals:  None
MSIC: 4
        20191202135429048.jpg
        20191202135435397.jpg
        20191202135442667.jpg
        20191202135446302.jpg
FTIR: 1
        20191202_135426_A.igm
IRLS: 1
        2019_12_02_13_54_27_R_04 TA=-3.3;TB=17.9;Gain=3
Gamma Runs:  None

-----------------------------------------------------------------------

Run: 5 Time: 14:00:46 UTC
        Alt: 2786 ft MSL  Elev: 8 ft  Elevation from DEM Database
        Vel: 107 knots  Heading: 355

Digitals:  None
MSIC: 4
        20191202140053100.jpg
        20191202140059449.jpg
        20191202140105814.jpg
        20191202140112163.jpg
FTIR: 1
        20191202_140050_A.igm
IRLS: 1
        2019_12_02_14_00_51_R_05 TA=-2.7;TB=17.3;Gain=3
Gamma Runs:  None

-----------------------------------------------------------------------

Run: 6 Time: 14:07:01 UTC
        Alt: 2741 ft MSL  Elev: 8 ft  Elevation from DEM Database
        Vel: 101 knots  Heading: 284
```

Digitals: None
MSIC: 5
        20191202140707167.jpg
        20191202140713517.jpg
        20191202140719881.jpg
        20191202140726231.jpg
        20191202140732580.jpg
FTIR: 1
        20191202_140704_A.igm
IRLS: 1
        2019_12_02_14_07_05_R_06 TA=-2.6;TB=17.4;Gain=3
Gamma Runs: None

Run: 7 Time: 14:16:24 UTC
        Alt: 2848 ft MSL Elev: 7 ft Elevation from DEM Database
        Vel: 100 knots Heading: 0

Digitals: None
MSIC: 4
        20191202141630078.jpg
        20191202141636443.jpg
        20191202141642792.jpg
        20191202141649142.jpg
FTIR: 1
        20191202_141627_A.igm
IRLS: 1
        2019_12_02_14_16_28_R_07 TA=-2.1;TB=17.9;Gain=3
Gamma Runs: None

Run: 8 Time: 14:24:37 UTC
        Alt: 2699 ft MSL Elev: 7 ft Elevation from DEM Database
        Vel: 108 knots Heading: 354

Digitals: None
MSIC: 5
        20191202142443080.jpg
        20191202142449445.jpg
        20191202142455795.jpg
        20191202142502144.jpg
        20191202142503064.jpg
FTIR: 1
        20191202_142440_A.igm
IRLS: 1
        2019_12_02_14_24_41_R_08 TA=-1.4;TB=18.6;Gain=3
Gamma Runs: None

Run: 9 Time: 14:31:36 UTC

Alt: 2697 ft MSL Elev: 9 ft Elevation from DEM Database
Vel: 106 knots Heading: 80

Digitals: None
MSIC: 5
20191202143142542.jpg
20191202143148907.jpg
20191202143155256.jpg
20191202143201606.jpg
20191202143207971.jpg
FTIR: 1
20191202_143140_A.igm
IRLS: 1
2019_12_02_14_31_40_R_09 TA=-0.9;TB=19.1;Gain=3
Gamma Runs: None

Run: 10 Time: 14:37:19 UTC
Alt: 2755 ft MSL Elev: 0 ft Elevation from DEM Database
Vel: 108 knots Heading: 35

Digitals: None
MSIC: 6
20191202143724828.jpg
20191202143731193.jpg
20191202143738447.jpg
20191202143744812.jpg
20191202143751162.jpg
20191202143757511.jpg
FTIR: 1
20191202_143722_A.igm
IRLS: 1
2019_12_02_14_37_23_R_10 TA=-0.3;TB=19.7;Gain=3
Gamma Runs: None

Flight Results for Flight 11, 02 December 2019

Weather Conditions and Crew Report

Weather for the mission is given in table 4.

Table 4. South 4 Group Mission Weather

Parameter	Surface (1500)	Surface (1600)
Wind direction	335 degrees	000 degrees
Wind speed	4.0 m/s (11 mph)	3.2 m/s (7 mph)
Temperature	16ºC	16ºC
Humidity	38%	29%
Dew Point	1,6ºC	2.2ºC
Pressure	1022 mb	1022
Ceiling	Clear	Clear

The crew reported that winds at altitude (2500 ft) were at about 19 kts (8.5 m/s) from the 000 degrees. Light gray smoke was observed from the site from one small fire and four water cannons.

Flight Status

The aircraft was airborne at 1523 (central) was over the site at 1532 (central). A total of 1 test and 8 data collection passes were completed. Flight information is summarized in Appendix Flight #11 and Figure 8.

Data Results

General Data Quality Objective

The following general data quality objectives are employed in conducting emergency response data collection with ASPECT:

1. To support overall situational analysis of the incident including aerial photography and IR imagery
2. To screen the incident for the presence of selected chemicals
3. To estimate the location and concentration of plumes being generated by the incident.

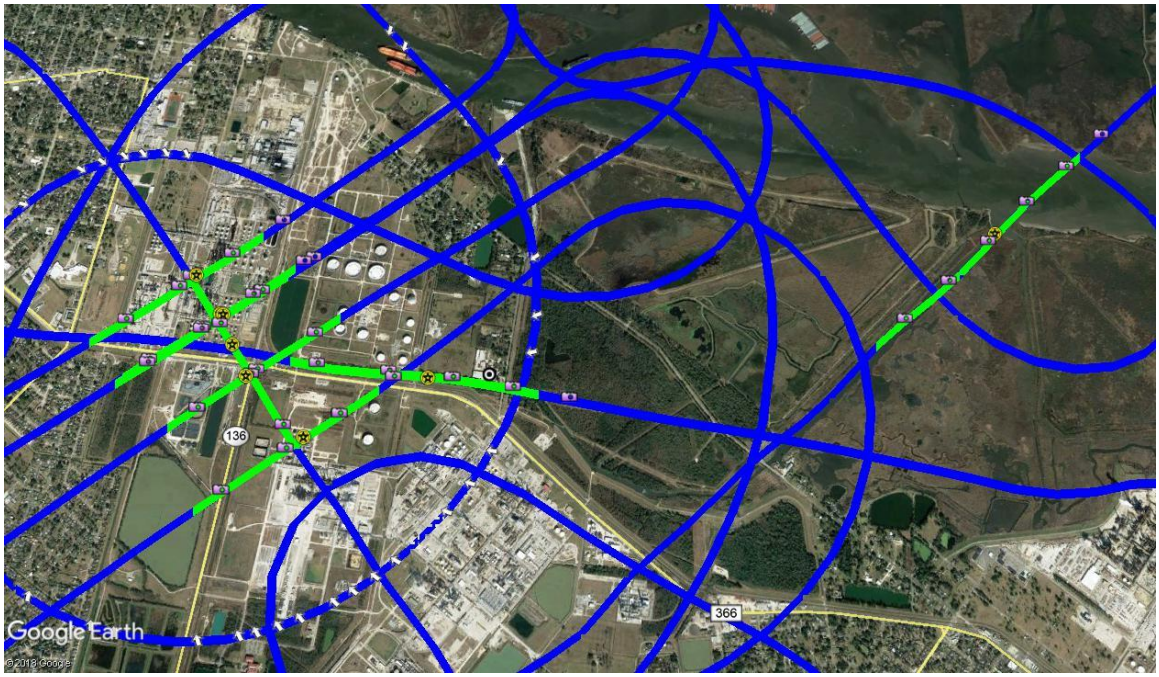

Figure 8: Data collection passes, Flight 11 South 4 Group Fire, Port Neches, TX. The blue lines represent the ASPECT flight path, green lines represent when the FTIR was actively collecting data, the yellow icons with star is the centroid of the line scanner image, and the camera icons represent when a photo was taken.

Line Scanner Data Results

A total of 2 test and 8 data collection passes were made in the proximity of the fire and an infrared line scanner image was generated for each pass. Figure 9 shows a typical 3-band infrared image obtained from data collected for Run 2. Examination of the frame shows that four water cannons are being used to cool the central part of the unit. No chemical plume can be observed being emitted from the facility. A close-up image taken from pass 7 is given in figure 10. The reactor towers tend to show temperature higher than the surround area with a defined high temperature location on the northern part the process unit. Figure 11 shows the waterway entry into the Naches River. Analysis of the image does not show a sheen but there does appear to be water flowing into the river.

FTIR Data Results

FTIR Spectral data at a resolution of 16 wavenumbers was collected for each pass. ASPECT uses an automated detection algorithm to permit compounds to be analyzed while the aircraft is in flight. 72 compounds are included in this algorithm and the list is given in Table 5. In addition, collected data are also manually analyzed by comparing any detected spectral signatures to a collection of published library spectra.

Signatures corresponding to isobutylene were detected due south of the facility near the wastewater treatment plant. Figure 12 shows the location of the detection cluster which had a maximum concentration of 1.57 ppm, just slightly above the detection limit of the system. A summary of data of the data collection is given in table 6.

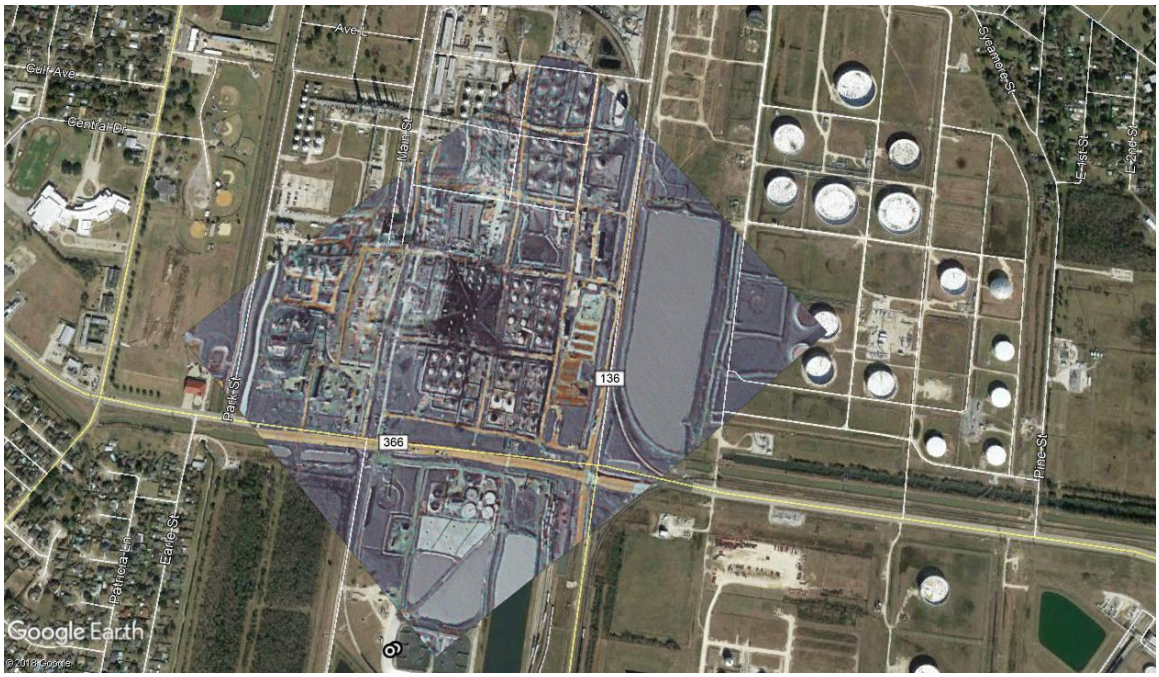

Figure 9: – 3 band IR image, Flight 11, Run 2, South 4 Group Fire

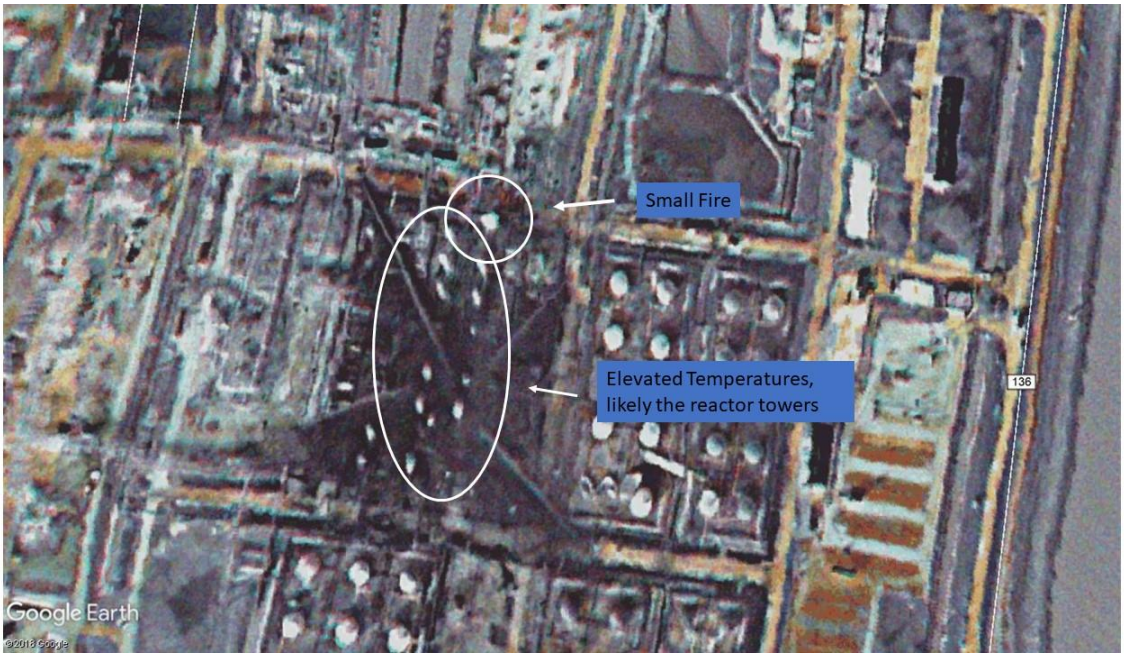

Figure 10: -- 3 band IR image, Flight 11, Run 7, South 4 Group Fire

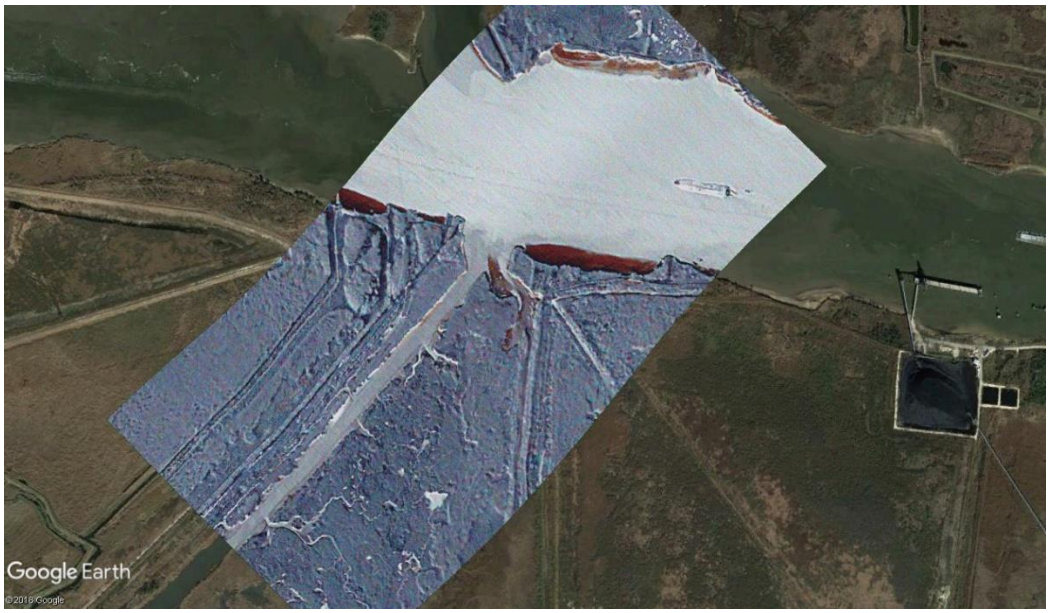

Figure 11: -- 3 band IR image, Flight 11, Run 10, Waterway, South 4 Group Fire

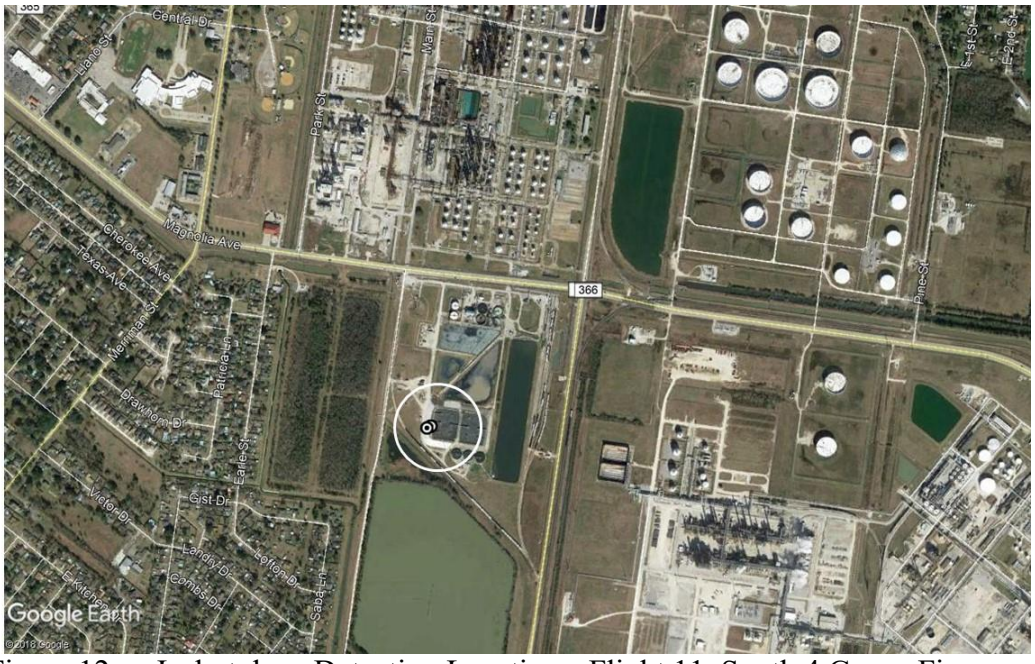

Figure 12: -- Isobutylene Detection Locations, Flight 11, South 4 Group Fire

TABLE 5 - Chemicals Included in the ASPECT Auto-Processing Library

Acetic Acid	Cumene	Isoprene	Propylene
Acetone	Diborane	Isopropanol	Propylene Oxide
Acrolein	1,1-Dichloroethene	Isopropyl Acetate	Silicon Tetrafluoride
Acrylonitrile	Dichloromethane	MAPP	Sulfur Dioxide
Acrylic Acid	Dichlorodifluoromethane	Methyl Acetate	Sulfur Hexafluoride
Allyl Alcohol	Difluoroethane	Methyl Ethyl Ketone	Sulfur Mustard
Ammonia	Difluoromethane	Methanol	Nitrogen Mustard
Arsine	Ethanol	Methylbromide	Phosgene
Bis-Chloroethyl Ether	Ethyl Acetate	Methylene Chloride	Phosphine
Boron Tribromide	Ethyl Formate	Methyl Methacrylate	Tetrachloroethylene
Boron Triflouride	Ethylene	MTEB	1,1,1-Trichloroethane
1,3-Butadiene	Formic Acid	Naphthalene	Trichloroethylene
1-Butene	Freon 134a	n-Butyl Acetate	Trichloromethane
2-Butene	GA (Tabun)	n-Butyl Alcohol	Triethylamine
Carbon Tetrachloride	GB (Sarin)	Nitric Acid	Triethylphosphate
Carbonyl Chloride	Germane	Nitrogen Trifluoride	Trimethylamine
Carbon Tetraflouride	Hexafluoroacetone	Phosphorus Oxychloride	Trimethyl Phosphite
Chlorodifluoromethane	Isobutylene	Propyl Acetate	Vinyl Acetate

Table 6. Chemical Results Summary

Run	Date	Time (UTC)	Chemical	Max Concentration ppm
1	2 Dec 2019	2137	Test	Test
2		2139	Test	Test
3		2153	ND	None
4		2158	Isobutylene	1.57
5		2202	ND	None
6		2207	ND	None
7		2212	ND	None
8		2217	ND	None
9		2222	ND	None
10		2227	ND	None
Note: ND = No Detections				

Aerial Photography Results

A full set of high resolution aerial digital photography were collected as part of the flight. Figure 13 shows a representative image collected as part of each pass. As reported by the flight crew, very light smoke is being generated by the fire. At the time of collection,

four large water cannons were dumping water into the middle of the process unit (figure 14). A smaller cannon was directing water on the fire located on the northern edge of the unit.

Conclusions – Flight 11

Flight 11 conducted on the afternoon of 2 December 2019 showed one fire on the northern edge of the process unit. A light gray smoke plume was still being emitted and at the time of the flight moving toward the southeast. Several of the reactor towers tended to show elevated temperatures as compared to the surrounding unit. IR imagery did not show any oil sheen presence on the Neches River but did suggest that water flow is going into the river. Analysis of FTIR data showed detections of isobutylene south of the facility near the wastewater treatment plant. These detections were approximately 1.57 ppm on two separate passes.

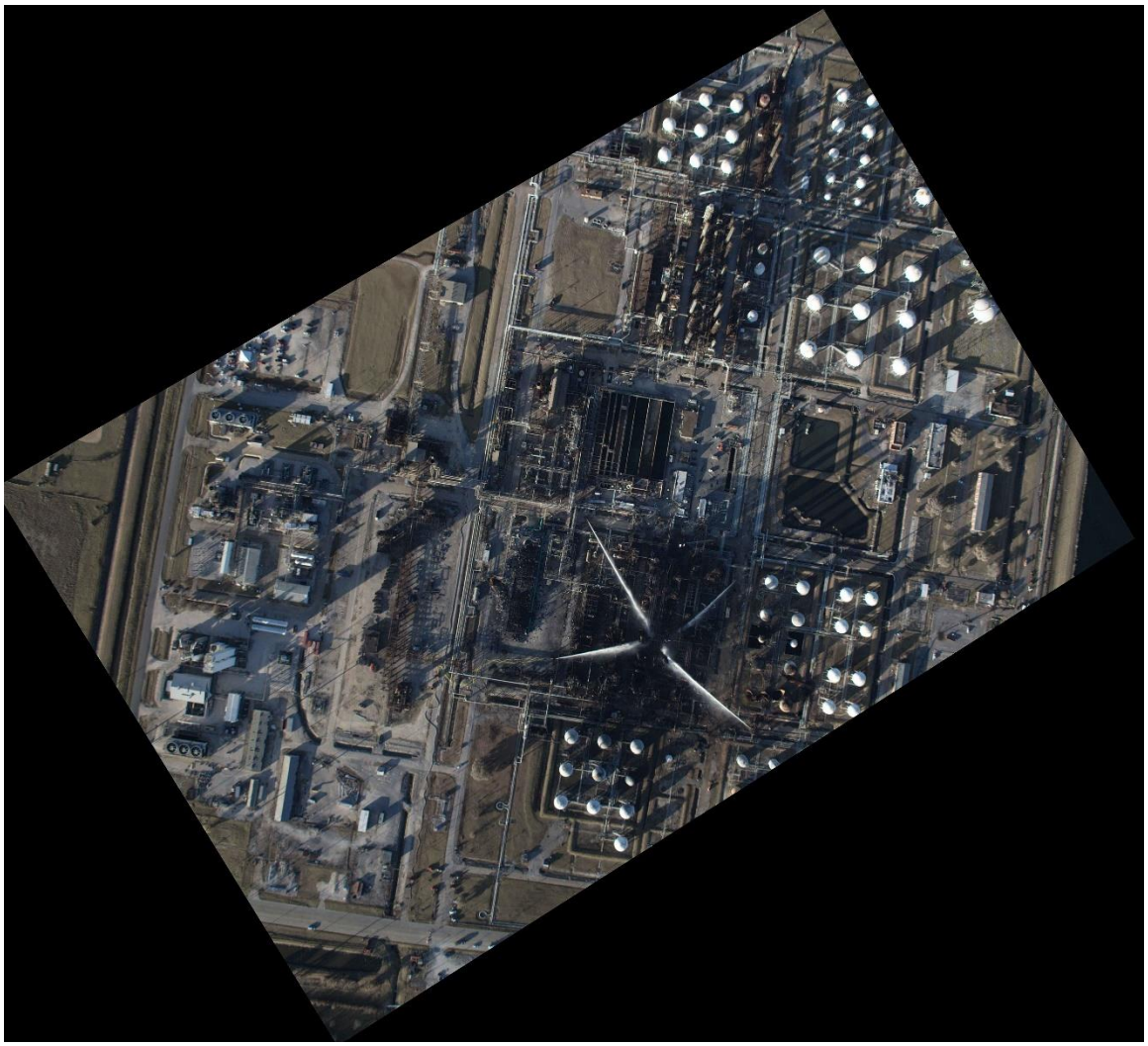

Figure 13: Aerial Image of the South 4Group Fire, Flight 11

Figure 14: Oblique Image of the South 4Group Fire, Flight 11

Appendix Flight #11

Abbreviations:

DEM – Digital elevation model
Alt – Altitude (in feet)
MSL – Mean sea level altitude (in feet)
Digital – Digital photography file from the Nikon D2X camera
MSIC – Digital photography file from the Imperx mapping camera
FTIR – Spectral IR data collected with a Fourier Transform Infrared Spectrometer
IRLS – Infrared Line Scanner
Jpg – JPEG image format
UTC – Universal Time Coordinated
img – Spectral data format based on Grams format

```
Mission:   2019-12-02 South 4 Group Fire

Date:      12/2/2019
Time UTC: 21:30

Aircraft Number: N9738B
Pilot: Todd Seale
Copilot: James Glaviano
Operator: James Crisp
Aft Operator: Gerry Broyles
Ground Controller: Ahmed Hafez

DEM: Using elevation from DEM Database
-----------------------------------------------------------------

Run: 1 Time: 21:37:44 UTC
        Alt: 2733 ft MSL  Elev: 5 ft  Elevation from DEM Database
        Vel: 153 knots  Heading: 278

Digitals:  None
MSIC: 3
        20191202213750135.jpg
        20191202213756499.jpg
        20191202213802848.jpg
FTIR: 1
        20191202_213747_A.igm
IRLS: 1
        2019_12_02_21_37_49_R_01 TA=13.0;TB=33.0;Gain=3
```

Gamma Runs: None

Run: 2 Time: 21:39:43 UTC
        Alt: 2695 ft MSL Elev: 8 ft Elevation from DEM Database
        Vel: 149 knots Heading: 288

Digitals: None
MSIC: 4
        20191202213949981.jpg
        20191202213956330.jpg
        20191202214002679.jpg
        20191202214009043.jpg
FTIR: 1
        20191202_213947_A.igm
IRLS: 1
        2019_12_02_21_39_48_R_02 TA=8.1;TB=24.8;Gain=3
Gamma Runs: None

Run: 3 Time: 21:53:23 UTC
        Alt: 2757 ft MSL Elev: 7 ft Elevation from DEM Database
        Vel: 109 knots Heading: 45

Digitals: None
MSIC: 4
        20191202215329766.jpg
        20191202215336115.jpg
        20191202215343384.jpg
        20191202215349733.jpg
FTIR: 1
        20191202_215326_A.igm
IRLS: 1
        2019_12_02_21_53_29_R_03 TA=5.6;TB=25.6;Gain=3
Gamma Runs: None

Run: 4 Time: 21:58:51 UTC
        Alt: 2732 ft MSL Elev: 7 ft Elevation from DEM Database
        Vel: 118 knots Heading: 238

Digitals: None
MSIC: 3
        20191202215857505.jpg
        20191202215903854.jpg
        20191202215910203.jpg
FTIR: 1
        20191202_215854_A.igm
IRLS: 1
        2019_12_02_21_58_56_R_04 TA=7.2;TB=27.2;Gain=3
Gamma Runs: None

Run: 5 Time: 22:02:19 UTC
        Alt: 2726 ft MSL Elev: 7 ft Elevation from DEM Database
        Vel: 105 knots Heading: 46

Digitals: None
MSIC: 4
        20191202220225396.jpg
        20191202220231760.jpg
        20191202220238109.jpg
        20191202220244458.jpg
FTIR: 1
        20191202_220222_A.igm
IRLS: 1
        2019_12_02_22_02_24_R_05 TA=6.7;TB=26.7;Gain=3
Gamma Runs: None

Run: 6 Time: 22:07:54 UTC
        Alt: 2756 ft MSL Elev: 6 ft Elevation from DEM Database
        Vel: 109 knots Heading: 46

Digitals: None
MSIC: 4
        20191202220759486.jpg
        20191202220806755.jpg
        20191202220813104.jpg
        20191202220819469.jpg
FTIR: 1
        20191202_220756_A.igm
IRLS: 1
        2019_12_02_22_07_59_R_06 TA=7.3;TB=27.3;Gain=3
Gamma Runs: None

Run: 7 Time: 22:12:46 UTC
        Alt: 2778 ft MSL Elev: 7 ft Elevation from DEM Database
        Vel: 111 knots Heading: 328

Digitals: None
MSIC: 4
        20191202221251817.jpg
        20191202221258181.jpg
        20191202221304530.jpg
        20191202221310895.jpg
FTIR: 1
        20191202_221249_A.igm
IRLS: 1
        2019_12_02_22_12_51_R_07 TA=6.6;TB=26.6;Gain=3
Gamma Runs: None

Run: 8 Time: 22:17:50 UTC
Alt: 2746 ft MSL Elev: 8 ft Elevation from DEM Database
Vel: 108 knots Heading: 44

Digitals: None
MSIC: 4
20191202221756862.jpg
20191202221803227.jpg
20191202221809575.jpg
20191202221815924.jpg
FTIR: 1
20191202_221753_A.igm
IRLS: 1
2019_12_02_22_17_55_R_08 TA=7.1;TB=27.1;Gain=3
Gamma Runs: None

Run: 9 Time: 22:22:18 UTC
Alt: 2652 ft MSL Elev: 9 ft Elevation from DEM Database
Vel: 110 knots Heading: 87

Digitals: None
MSIC: 5
20191202222223782.jpg
20191202222231035.jpg
20191202222237400.jpg
20191202222243749.jpg
20191202222250098.jpg
FTIR: 1
20191202_222221_A.igm
IRLS: 1
2019_12_02_22_22_23_R_09 TA=6.9;TB=26.9;Gain=3
Gamma Runs: None

Run: 10 Time: 22:27:33 UTC
Alt: 2707 ft MSL Elev: 0 ft Elevation from DEM Database
Vel: 108 knots Heading: 39

Digitals: None
MSIC: 6
20191202222739718.jpg
20191202222746067.jpg
20191202222752432.jpg
20191202222758781.jpg
20191202222805145.jpg
20191202222811494.jpg
FTIR: 1
20191202_222735_A.igm

IRLS: 1
2019_12_02_22_27_38_R_10 TA=5.8;TB=25.8;Gain=3
Gamma Runs: None